TFL 35 inventory audit

Introduction

An inventory is conducted by the licensee of each Tree Farm License (TFL) in British Columbia every 10 to 30 years—using standards and procedures that are approved by the Ministry of Forests—with regular updates to reflect changes in the timber volume due to growth and to depletions from harvesting and natural causes.

This report presents the results of an inventory audit performed within TFL 35. Managed by Weyerhauser Canada Ltd., TFL 35 is located approximately 40 kilometers north of Kamloops in the Kamloops Forest Region and covers an area of approximately 36 460 hectares.

Purpose of the audit and application of the results

It is often asked, "How accurate is the current inventory?" To answer this important question, the Ministry of Forests has developed an inventory audit methodology specifically designed to test the overall accuracy of estimates of the total standing volume in each timber supply area.

This inventory audit methodology entails sampling three primary components of the inventory: mature forests, immature forests and non-forest areas.

The objective of the inventory audits program is to help identify TFLs or TSAs where the forest inventory needs attention. Enough samples are taken to ensure statistically reliable results for the TFL as a whole.

The amount of data collected, however, is not sufficient to make statistically reliable conclusions about specific areas or tree species. For example, any overall differences highlighted by the audit could result from problems with one tree species, from part of the land base (such as high elevation rather than lower elevation areas), from one age group of forest stands, or from a combination of these and other factors. As a consequence, general audit results cannot appropriately be used to adjust information about the forests currently available for timber harvesting since this area constitutes only a portion of the total forested area in the TFL.

The audits provide information that may be useful to the chief forester during determinations of the allowable annual cut—offering a general assessment of the uncertainty associated with mature timber volumes, immature site index, and the non-forest classification. However, the audit results cannot justifiably be used to make specific adjustments to growth and yield and other information used in timber supply analysis and allowable annual cut determinations.

Methods

Current inventory

There are 35 TFLs in British Columbia, varying in size from approximately 8 500 ha to just over 1 000 000 ha. Inventories are conducted on each TFL by the licensee through a multistage process. Although the methodology varies within each TFL, all standards must be approved by the Ministry of Forests. New standards currently under development will ensure a consistent minimum standard for all TFLs. Generally, polygons (a boundary drawn around a forest stand of similar characteristics) are first delineated from 1:15 000 or 1:10 000 scale aerial photographs. Photo-interpretation is then used to produce data on a number of attributes for each polygon. These attributes generally include species composition, stand height, age, and crown closure. Timber volume is then estimated indirectly using the photo-interpreted variables and an empirical yield model. Other approaches to volume estimation, approved by the Ministry of Forests, may also be used.

To keep estimates current, inventories are regularly updated to account for forest growth, and for depletions due to harvesting, fire losses, and the impact of insects and disease. Empirical yield models, such as the Ministry of Forests Variable Density Yield Prediction (VDYP) computer model, are used to update the inventory for forest growth. Field visits, satellite imagery and aerial photographs may be used to update the inventory for depletion.

Inventory audit procedures

The inventory audit tests three components of the current inventory. The first component is the mature forested areas (forest stands greater than 60 years of age). The inventory audit will test the accuracy of the mature timber volume. The second component tested is immature stands (less than 60 years of age but greater than the silvicultural classification of free growing). The audit will test the accuracy of the site growth potential (site index) assignment for these stands. The third audit test is of the photo-classification accuracy of the non-forest classification component of the inventory (areas such as lakes,

Province of
British Columbia
Ministry
of Forests

106-06860/

gravel pits and alpine meadows).

Mature component assessment criteria

Testing the mature component of the inventory compares the existing inventory's estimate of the mean mature volume per hectare for the TFL (called the *inventory volume*), and a new estimate of the mean mature volume per hectare for the TFL obtained from the audit samples (called the *audit volume*).

The difference between these two estimates is called the total bias. A test is conducted on this bias to determine if it is statistically significant. This test establishes whether there are detectable differences between the audit volume estimate and the inventory volume estimate, for the total forested area of the TFL.

Immature component assessment criteria

Accuracy of the inventory classification for immature stands is tested by examining the site index assignment. Since the immature forest stand site index provides an estimate of site productivity, its accuracy affects the projection of long-term harvest levels.

Data gathered is examined to determine how closely the audit and inventory site indices match for individual samples, and to explore potential trends.

Non-forest component assessment criteria

The audit test for the non-forest component of the inventory assesses the accuracy of the non-forest classification assignment. An air photo interpreter certified by the Ministry of Forests compares the non-forest inventory classification to a suitably-scaled forest cover aerial photograph. Classification accuracy is rated from a point scoring scheme to determine an overall accuracy percentage. The acceptance criteria for this test is 85% or higher.

TFL 35 audit sampling procedures

The TFL 35 sample was based on files updated from the most recent inventory. A list of all polygons identified on these files was produced and sorted on a number of stand characteristics (site quality, age, and species group). Polygons were systematically selected from this list by a process designed to produce a representative sample of the TFL.

For the mature forested component of the inventory audit, a random sample of 50 forested polygons from the total forested area in the TFL were selected for sampling.

Up to four full-measure prism plots, and five count plots, were established within each of the 50 sample polygons. The plots were located systematically, using a square grid and a random start point. The grid interval distance varied with polygon size. To reduce sample costs for large or irregular polygons, only a randomly selected portion of the polygon was sampled. In total, about 200 full-measure and 250 count plots were established. Field data collection and compilation followed Ministry of Forests cruising and cruise compilation procedures. The objective was to obtain audit volumes that were comparable (in terms of utilization standards and merchantability definitions) to the inventory volumes that are produced by the licensee.

In the case of TFL 35, and many other TFLs within the province, polygon-specific inventory volumes are not available to correspond to all audit samples. Across much of the inventory area, the polygons are aggregated into large analysis units and volume estimates are computed using empirical yield equations specific to each analysis unit. For each of the inventory audit samples, the licensee provided the appropriate analysis unit volume. As a result, in TFL 35, the *analysis unit volumes* replaced inventory volumes in the standard inventory audit comparisons. Utilization standards comparable to the licensee's were applied in the compilation of the audit data to produce the audit volumes.

The audit volume estimates were then compared to the analysis unit volumes to test the validity of the current inventory. Ratios of the audit volume to analysis unit volume were calculated to test for significant differences. The precision of the analysis unit volume estimates—how well the analysis unit estimate corresponds to the audit volume estimate on a sample by sample basis—were assessed by measuring their statistical correlation. The data was then post-stratified to detect trends related to the operable and inoperable forested land base distribution of the sampled polygons.

From the immature forested component, a random sample of 20 polygons were selected for sampling. Up to six inventory ground calls were established within each of the 20 sample polygons. The plots were located along a single transect line that was considered representative of the site productivity (site index) of the stand. In total, approximately 120 ground calls were established. Field data collection followed the standard Ministry of Forests inventory ground call procedures. The location of the sample transect was subjective. Since the magnitude of bias caused by this process is unknown, the reported results and their interpretations for the immature forested component of the inventory should be used with caution.

For the audit of the non-forest component of the inventory, a random sample of 30 non-forest polygons were selected. Standard Ministry of Forests inventory air photo classification techniques were used to compare the 30 non-forest polygon classification assignments to corresponding air photo checks.

Inventory audit results

Analysis of mature volumes

The results of the inventory audit for mature volume statistical analyses for the total forested area are given in Table 1.

	Audit Volume Estimate	Analysis Unit Volume Estimate
Number of Samples	50	50
Mean (m^3/ha)	287	284
Coefficient of variation (%)	41	32
Standard error	16.60	13.05
Sampling Error (%)	11.6	9.2
95% Confidence Interval (m^3/ha)	253–320	258–310

Correlation coefficient r = 0.340
Ratio of means (audit/analysis unit volume estimates) = 1.01

Table 1: Statistics for the audit volume and analysis unit volume estimates for TFL 35.

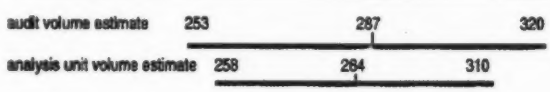

Table 2: Bar graph representation of 95% confidence intervals in m^3/ha

The calculated correlation coefficient of 0.340 for the audit and the analysis unit volume estimate indicates a weak but statistically significant relationship among the individual samples. There is a 3 m^3/ha difference between the means of the inventory estimate for mature volume (284 m^3/ha) and the audit estimate (287 m^3/ha). This difference is not statistically significant, 19 times out of 20 for the mature component of the total forested area of the TFL.

Analysis of operable and inoperable volumes

To provide audit results more likely to be applicable to the timber supply planning process, an approximation was made of the forested areas considered currently available for timber harvesting (called *operable* areas). The audit results were post-stratified based on this approximation. However, since all 50 samples were within the operable forested area, the results presented in Table 1 are identical for the operable forested area.

Analysis of immature inventory classification

Out of 20 stands sampled in the field, four stands were considered too young to accurately assess a site index . Of the remaining 16 stands, the inventory correctly identified site index within ±3 m of the audit site index for 10 stands. The inventory site index was more than 3 m lower than the audit site index for two stands and more than 2 m higher in four stands.

Analysis of non-forest inventory classification

Thirty stands classified as non-forest were assessed for their inventory assignment accuracy. The resulting score was 86%, which meets the provincial minimum standard of 85%.

Discussion and conclusions

The objective of the inventory audit in TFL 35 was to assess the overall accuracy of the current inventory. The mature, immature and non-forested components were tested.

The results of the audit for the mature component of the inventory suggest that the inventory is statistically acceptable. Subsequent analysis of post-stratified data also show a similar level of acceptability in the operable forested area.

Audit results for the immature component of the inventory suggests an acceptable level of accuracy for site index assignment in young stands. The audit assessment of the non-forest classification in the TSA found it to be within provincial standards.

Glossary

accuracy: A measure of the closeness of an estimate to the true value.

allowable annual cut: The rate of timber harvesting specified for an area of land.

analysis unit: The basic building block around which inventory data and other information are assembled for use in forest planning models. Analysis units represent the general level of aggregation, or detail, at which a timber supply analysis is carried out. They are normally defined by tree species and site qualities.

bias: The quality of a measurement device or procedures that tends to result in a systematic misrepresentation of what is being measured.

coefficient of variation: A relative measure of the variation of the population calculated as the ratio between the standard deviation and the mean value.

confidence interval: The range of values within which the population parameter is expected to lie.

confidence level: The estimated probability that a population parameter lies within a given confidence interval.

correlation coefficient: A measure of the relationship between two variables. A value of 0 for the correlation coefficient indicates a random relationship whereas a

value of ±1 indicates a perfect positive or negative linear correspondence.

diameter at breast height (dbh): The stem diameter (outside-bark) of a tree measured at breast height (1.3 metres above the point of germination) to the nearest millimetre.

field visitations: Ground level field procedures designed to provide physical verification of polygon inventory attributes.

free growing (crop): A crop of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs or other trees.

inoperable: Refers to areas having merchantable timber that cannot be harvested economically using current harvesting technology because of some physical barrier (such as a hanging valley), and to areas containing small patches of overmature timber surrounded by large areas of young stands.

mean: The average value of a set of observations.

pre-inventory assessments: Pre-inventory analyses are inventory activities to evaluate the existing forest inventory as the basis for deciding whether to re-inventory or update the current inventory, and to document the existing inventory, maps, and photos to support the execution of the reinventory or update if required.

ratio estimate: The ratio between two different estimates.

representative: The quality of a sample having the same characteristics as the population from which it is selected.

sampling: The process of selecting observations.

sampling error: The error attributed to sampling procedures.

significant difference: An expression used in reference to the results of a statistical test in which either two or more estimates are compared or an estimate is compared to a fixed value. If the observed difference is greater than what might be expected as a chance occurrence due to the sampling procedures, the difference is said to be statistically significant.

site index: A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.

standard error: An expression of the absolute variability of an estimate.

standard deviation: A measure of the variation of the population.

timber supply analysis: The technical process of amalgamating land management information into computer systems that predict the amount of timber available for harvest over given time periods.

timber supply area: An integrated resource management unit established in accordance with section 6 of the *Forest Act*.

tree farm license: An integrated resource management unit established in accordance with section 28 of the *Forest Act*.

For more information

For more information or to obtain other inventory audit reports, contact: Director, Resources Inventory Branch, 722 Johnson Street, Victoria, B.C., Canada V8W 3E7, 387-1314, fax 387-5999, or e-mail to RIBinfo@galaxy.gov.bc.ca.